

What is Claimed Is:

- 1 1. An apparatus, comprising:
2 means for transmitting data blocks to a receiver;
3 means for receiving messages identifying successfully received data
4 blocks; and
5 means for retransmitting a data block to the receiver in response to
6 absence of receipt, within a predetermined time referenced to the time of transmission
7 of the data block, of a message identifying the data block as having been successfully
8 received.
- 1 2. Apparatus as in claim 1, wherein the retransmitted data block is part
2 of a data packet and said retransmitting means retransmits the data block before
3 a delay bound set for the data packet
- 1 3. Apparatus as in claim 1, wherein said means for retransmitting
2 includes:
3 means responsive to absence of receipt by the end of a first interval of
4 time, of a message that a data block has been successfully received, for transmitting to
5 the receiver a request for a message identifying successfully received data blocks, and

6 means responsive to continued absence of receipt by the end of a second
7 and later interval of time, of a message that the data block has been successfully
8 received, for retransmitting the data block to the receiver.

1 4. Apparatus as in claim 3, wherein said first and second intervals of
2 time are referenced to the time of transmission of the data block.

1 5. Apparatus as in claim 3, wherein:
2 said first interval of time is referenced to the time of transmission to the
3 receiver of the data block, and
4 said second interval of time is referenced to the time of transmission to
5 the receiver of the request for a message identifying successfully received data blocks.

1 6. Apparatus as in claim 5, wherein the data block is part of a data
2 packet and said second interval of time ends before a delay bound set for the data
3 packet

1 7. Apparatus as in claim 6, wherein:
2 said first interval of time expires at a time $A+D-T_I$, where A is the
3 arrival time at said means for transmitting of the data packet, D is the delay bound
4 time set for the data packet and T_I is a threshold value, and

5 said second interval of time expires at a time $A+D-T_2$, where T_2 is a
6 threshold value lower than T_1

1 8. Apparatus as in claim 1, wherein said transmitting means transmits to
2 the receiver sequentially identified data blocks and said retransmitting means is
3 inoperative to retransmit a data block M upon said receiving means receiving a
4 message that either:

5 data block N has been successfully received, and $M \leq N$, or
6 data block P has been successfully received, and $M \leq P+1$.

1 9. Apparatus as in claim 1, further including:

2 means for receiving negative acknowledgement messages from the
3 receiver identifying data blocks that have not been successfully received, the negative
4 acknowledgement messages including an identification of successfully received data
5 blocks,

6 said means for retransmitting being responsive to receipt of a negative
7 acknowledgement message that a data block has not been successfully received to
8 retransmit the data block to the receiver.

1 10. A transmitter, comprising:

2 a transmitter circuit for transmitting data blocks to a receiver and for
3 receiving from the receiver messages identifying successfully received data blocks;
4 and

5 a timer circuit,

6 said transmitter circuit retransmitting a data block to the receiver in
7 response to absence of receipt from the receiver, by a time determined by said timer
8 circuit and referenced to the time of transmission of the data block, of a message
9 identifying the data block as having been successfully received.

1 11. A transmitter as in claim 10, wherein said transmitter circuit is:

2 responsive to absence of receipt by the end of a first interval of time
3 determined by said timer circuit, of a message from the receiver that a data block has
4 been successfully received, to transmit to the receiver a request for a message
5 identifying successfully received data blocks, and is

6 responsive to continued absence of receipt by the end of a second and
7 later interval of time determined by said timer circuit, of a message from the receiver
8 that the data block has been successfully received, to retransmit the data block to the
9 receiver

1 12. A transmitter as in claim 11, wherein said first and second intervals
2 of time are referenced to the time of transmission to the receiver of the data block.

1 13. A transmitter as in claim 11, wherein:
2 said first interval of time is referenced to the time of transmission to the
3 receiver of the data block, and
4 said second interval of time is referenced to the time of transmission to
5 the receiver of the request for a message identifying successfully received data blocks.

1 14. A transmitter as in claim 13, wherein the data block is part of a data
2 packet and said second interval of time ends before a delay bound set for the data
3 packet.

1 15. A transmitter as in claim 14, wherein:
2 said first interval of time expires at a time $A+D-T_1$, where A is the
3 arrival time of the data packet at said transmitter control circuit, D is the delay bound
4 time set for the data packet and T_1 is a threshold value, and
5 said second interval of time expires at a time $A+D-T_2$, where T_2 is a
6 threshold value lower than T_1 .

1 16. A transmitter as in claim 10, wherein said transmitter circuit
2 transmits sequentially identified data blocks, and is inoperative to retransmit a data
3 block M upon receiving from the receiver a message that either:

4 data block N has been successfully received, and $M \leq N$, or

5 data block P has been successfully received, and $M \leq P + 1$.

1 17. A transmitter as in claim 10, wherein said transmitter circuit is
2 responsive to receipt from the receiver of negative acknowledgement messages
3 identifying data blocks that have not been successfully received, to retransmit the
4 identified data blocks to the receiver, the negative acknowledgement messages
5 including identifications of successfully received data blocks.

1 18. A transmitter as in claim 10, further comprising:
2 a data block storage buffer for storing copies of transmitted data blocks,
3 said transmitter circuit obtaining, from said data block storage buffer, data blocks for
4 retransmission.

1 19. A transmitter as in claim 10, wherein said transmitter circuit, upon
2 transmission of each data block to the receiver, controls said timer circuit to start an
3 acknowledgement timer associated with the transmitted data block.

1 20. A transmitter as in claim 19, wherein said transmitter circuit, in
2 response to receipt before expiry of an acknowledgement timer of a message from the
3 receiver that the associated data block has been successfully received, controls said
4 timer circuit to cancel the acknowledgement timer.

1 21. A transmitter as in claim 20, wherein said transmitter circuit, in the
2 absence of receipt before expiry of an acknowledgement timer of a message from the
3 receiver that the associated data block has been successfully received, transmits to the
4 receiver a request for a message identifying successfully received data blocks and
5 controls said timer circuit to start an associated panic timer.

1 22. A transmitter as in claim 21, wherein said transmitter circuit, in
2 response to receipt before expiry of a panic timer of a message from the receiver that
3 the associated data block has been successfully received, controls said timer circuit to
4 cancel the panic timer.

1 23. A transmitter as in claim 22, wherein said transmitter circuit, in the
2 absence of receipt before expiry of a panic timer of a message from the receiver that
3 the associated data block has been successfully received, retransmits the associated
4 data block to the receiver.

1 24. Apparatus for transmitting data over a network, comprising:
2 a transmitter for transmitting data blocks; and
3 a receiver for receiving the transmitted data blocks, said receiver being
4 operable to send to said transmitter messages identifying successfully received data
5 blocks,
6 said transmitter retransmitting a data block to the receiver in response to
7 absence of receipt by said transmitter, by a time determined by said timer circuit and
8 referenced to the time of transmission of the data block, of a message from said
9 receiver identifying the data block as having been successfully received.

1 25. Apparatus as in claim 24, wherein said transmitter includes:
2 a transmitter control circuit; and
3 a data block storage buffer for storing copies of transmitted data blocks,
4 said transmitter control circuit obtaining from said data block storage buffer data
5 blocks for retransmission to said receiver.

1 26. Apparatus as in claim 24, wherein said transmitter includes:
2 a transmitter control circuit; and
3 a timer circuit,
4 said transmitter control circuit being responsive to absence of receipt by
5 the end of a first interval of time determined by said timer circuit, of a message from

6 said receiver that a data block has been successfully received, to transmit to the
7 receiver a request for a message identifying successfully received data blocks, and
8 being responsive to continued absence of receipt by the end of a second and later
9 interval of time determined by said timer circuit, of a message from said receiver that
10 the data block has been successfully received, to retransmit the data block to said
11 receiver.

1 27. Apparatus as in claim 26, wherein said first and second time
2 intervals are referenced to the time of transmission by said transmitter to said receiver
3 of the data block.

1 28. Apparatus as in claim 26, wherein said first time interval is
2 referenced to the time of transmission by said transmitter to said receiver of the data
3 block, and said second time interval is referenced to the time of transmission by said
4 transmitter to said receiver of the request for the message identifying successfully
5 received data blocks.

1 29. Apparatus as in claim 26, wherein the data block is part of a data
2 packet and said second interval of time ends before a delay bound set for the data
3 packet.

1 30. Apparatus as in claim 29, wherein:

2 said first interval of time expires at a time $A+D-T_1$, where A is the
3 arrival time of the data packet at said transmitter, D is the delay bound time set for the
4 data packet and T_1 is a threshold value, and

5 said second interval of time expires at a time $A+D-T_2$, where T_2 is a
6 threshold value lower than T_1 .

1 31. Apparatus as in claim 24, wherein said transmitter transmits to said
2 receiver sequentially identified data blocks, and is inoperative to retransmit a data
3 block M upon receiving from said receiver a message that either:

4 data block N has been successfully received, and $M \leq N$, or

5 data block P has been successfully received, and $M \leq P+1$.

1 32. Apparatus as in claim 24, wherein said transmitter is responsive to
2 receipt from said receiver of negative acknowledgement messages identifying data
3 blocks that have not been successfully received, to retransmit the data blocks to said
4 receiver, the negative acknowledgement messages including identifications of
5 successfully received data blocks.

1 33. Apparatus as in claim 24, wherein said transmitter includes:

2 a timer circuit,

3 said transmitter, in response to transmission of each data block to said
4 receiver, controlling said timer circuit to start an acknowledgement timer associated
5 with the transmitted data block.

1 34. Apparatus as in claim 33, wherein said transmitter, in response to
2 receipt before expiry of an acknowledgement timer of a message from said receiver
3 that the associated data block has been successfully received, controls said timer
4 circuit to cancel the acknowledgement timer.

1 35. Apparatus as in claim 34, wherein said transmitter, in the absence of
2 receipt before expiry of an acknowledgement timer of a message from said receiver
3 that the associated data block has been successfully received, transmits to said
4 receiver a request for a message identifying successfully received data blocks, and
5 controls said timer circuit to start an associated panic timer.

1 36. Apparatus as in claim 35, wherein said transmitter, in response to
2 receipt before expiry of a panic timer of a message from said receiver that the
3 associated data block has been successfully received, controls said timer circuit to
4 cancel the panic timer.

1 37. Apparatus as in claim 36, wherein said transmitter, in the absence of
2 receipt before expiry of a panic timer of a message from said receiver that the
3 associated data block has been successfully received, retransmits the associated data
4 block to said receiver.

1 38. Apparatus as in claim 24, wherein said transmitter transmits
2 sequentially identified data blocks to said receiver and said receiver, in the messages
3 sent to said transmitter identifying successfully received data blocks, identifies the
4 most recent data block received.

1 39. Apparatus as in claim 38, wherein said receiver periodically sends
2 to said transmitter a message identifying the most recent data block received.

1 40. Apparatus as in claim 24, wherein:
2 said receiver sends to said transmitter negative acknowledgement
3 messages identifying data blocks that said receiver has not successfully received, and
4 said transmitter is responsive to receipt of a negative acknowledgement
5 message to retransmit to said receiver the data block identified as not having been
6 successfully received,
7 the negative acknowledgement messages including identifications of
8 successfully received data blocks.

1 41. A method, comprising:
2 transmitting data blocks to a receiver;
3 receiving from the receiver messages identifying successfully received
4 data blocks; and
5 retransmitting a data block to the receiver in response to absence of
6 receipt by a predetermined time referenced to the time of transmission of the data
7 block, of a message from the receiver identifying the data block as having been
8 successfully received.

1 42. A method as in claim 41, wherein the data block is part of a data
2 packet and said retransmitting step retransmits the data block before a delay bound set
3 for the data packet.

1 43. A method as in claim 41, including the step of:
2 sending to the receiver, in response to absence of receipt by the end of a
3 first interval of time of a message from the receiver identifying a data block as having
4 been successfully received, a request for a message identifying successfully received
5 data blocks, and wherein
6 said retransmitting step is responsive to continued absence of receipt by
7 the end of a second and later interval of time, of a message from the receiver that the
8 data block has been successfully received, to retransmit the data block to the receiver.

1 44. A method as in claim 43, wherein the first time interval is
2 referenced to the time of performance of said transmitting step for the data block and
3 the second time interval is referenced to the time of performance of said sending step
4 for the data block.

1 45. A method as in claim 44, wherein the data block is part of a data
2 packet and the second time interval ends before a delay bound set for the data packet.

1 46. A method as in claim 41, including the steps of:
2 receiving from the receiver negative acknowledgement messages
3 identifying data blocks that have not been successfully received; and
4 retransmitting the identified data blocks to the receiver in response to
5 receipt of the negative acknowledgement messages, and wherein
6 the negative acknowledgement messages include identifications of
7 successfully received data blocks.

1 47. A method as in claim 41, including the step of:
2 separating data packets into data blocks, and wherein
3 said transmitting step transmits the data blocks sequentially.

1 48. A method as in claim 41, including the step of:
2 storing copies of transmitted data blocks, and wherein
3 said retransmitting step includes obtaining a stored copy of a data block
4 for retransmission.

1 49. A method as in claim 41, including the step of:
2 starting, upon each performance of said transmitting step, an
3 acknowledgement timer associated with the transmitted data block.

1 50. A method as in claim 49, including the step of:
2 canceling an acknowledgment timer in response to receipt, before expiry
3 of the acknowledgment timer, of a message from the receiver that the associated data
4 block has been successfully received.

1 51. A method as in claim 50, including the steps of:
2 sending to the receiver, in response to expiration of an
3 acknowledgement timer in the absence of receipt before expiry of the
4 acknowledgement timer of a message from the receiver that the associated data block
5 has been successfully received, a request for a message identifying successfully
6 received data blocks, and
7 starting a panic timer associated with the data block.

1 52. A method as in claim 51, including the step of:
2 canceling a panic timer associated with a data block in response to
3 receipt, before expiry of the panic timer, of a message from the receiver identifying
4 the data block as having been successfully received.

1 53. A method as in claim 51, including the step of:
2 retransmitting, in 52 to receipt before expiry of a panic timer of a
3 message from the receiver that the associated data block has been successfully
4 received, the associated data block to the receiver.

1 54. A method as in claim 41, including the step of:
2 periodically sending from the receiver to the transmitter messages
3 identifying successfully received data blocks.

1 55. A transmitter as in claim 44, wherein:
2 the first interval of time expires at a time $A+D-T_1$, where A is the arrival
3 time of the data packet for transmission by said transmitting step, D is the delay bound
4 time set for the data packet and T_1 is a threshold value, and
5 the second interval of time expires at a time $A+D-T_2$, where T_2 is a
6 threshold value lower than T_1 .

1 56. A method as in claim 41, wherein said transmitting step transmits
2 sequentially identified data blocks, and said retransmitting step is inoperative to
3 retransmit a data block M upon receiving a message that either:

4 data block N has been successfully received, and $M \leq N$, or

5 data block P has been successfully received, and $M \leq P+1$.

1 57. A method, comprising:

2 transmitting data blocks from a transmitter to a receiver;

3 sending messages from the receiver to the transmitter identifying
4 successfully received data blocks; and

5 retransmitting a data block to the receiver in response to absence of
6 receipt at the transmitter, by a predetermined time referenced to the time of
7 transmission of the data block, of a message from the receiver identifying the data
8 block as having been successfully received.

1 58 A method as in claim 57, wherein the data blocks are constituent part
2 of data packets and the predetermined time is shorter than a delay bound set for the
3 data packets.

1 59. A method as in claim 57, including the step of:
2 storing copies of transmitted data blocks, and wherein said
3 retransmitting step obtains a stored copy of a data block for retransmission.

1 60. A method as in claim 57, including the step of:
2 sending to the receiver, in response to absence of receipt by the end of a
3 first interval of time of a message from the receiver identifying a data block as having
4 been successfully received, a request for a message identifying successfully received
5 data blocks, and wherein
6 said retransmitting step is responsive to continued absence of receipt by
7 the end of a second and later interval of time, of a message from the receiver that the
8 data block has been successfully received, to retransmit the data block to the receiver.

1 61. A method as in claim 60, wherein the first and second time intervals
2 are referenced to the time of performance of said transmitting step for the data block.

1 62. A method as in claim 60, wherein the first time interval begins with
2 performance of said transmitting step for the data block, and the second time interval
3 begins with performance of said sending step for the data block.

1 63. A method as in claim 60, wherein the data block is part of a data
2 packet and the second time interval ends before a delay bound set for the data packet.

1 64. A method as in claim 57 including the steps of:
2 sending from the receiver to the transmitter negative acknowledgement
3 messages identifying data blocks that have not been successfully received; and
4 retransmitting the identified data blocks from the transmitter to the
5 receiver in response to receipt of the negative acknowledgement messages, and
6 wherein
7 the negative acknowledgement messages include identifications of
8 successfully received data blocks

1 65. A method as in claim 57, including the step of:
2 starting, upon each performance of said transmitting step, an
3 acknowledgement timer associated with the transmitted data block.

1 66. A method as in claim 65, including the step of:
2 canceling an acknowledgment timer in response to receipt, before expiry
3 of the acknowledgment timer, of a message from the receiver that the associated data
4 block has been successfully received.

1 67. A method as in claim 66, including the steps of:

2 sending to the receiver, in response to expiration of an
3 acknowledgement timer in the absence of receipt before expiry of the
4 acknowledgement timer of a message from the receiver that the associated data block
5 has been successfully received, a request for a message identifying successfully
6 received data blocks, and

7 starting a panic timer associated with the data block.

1 68. A method as in claim 67, including the step of:

2 canceling a panic timer associated with a data block in response to
3 receipt, before expiry of the panic timer, of a message from the receiver identifying
4 the data block as having been successfully received.

1 69. A method as in claim 68, including the step of:

2 retransmitting, in response to expiry of a panic timer, the associated data
3 block to the receiver

1 70. A method as in claim 57, including the step of:

2 periodically sending from the receiver to the transmitter an identification
3 of successfully received data blocks.

1 71. A method as in claim 57, including the steps of:
2 sequentially identifying data blocks transmitted to the receiver, and
3 periodically sending from the receiver to the transmitter an
4 acknowledgement message identifying the most recent data block received.

1 72. A method as in claim 57, wherein:
2 said sending step includes sending from the receiver to the transmitter
3 negative acknowledgement messages identifying data blocks that have not been
4 successfully received, and
5 said retransmitting step includes retransmitting the identified data
6 blocks.

1 73. A method as in claim 72, including the steps of:
2 setting a negative acknowledgement timer in response to sending a
3 negative acknowledgement message from the receiver to the transmitter, and
4 resending the negative acknowledgement message from the receiver to
5 the transmitter in the absence of receiving at the receiver, by the time of expiry of the
6 negative acknowledgement timer, a retransmission of the identified data block.

1 74. A method as in claim 62, wherein:
2 the first interval of time expires at a time $A+D-T_1$, where A is the arrival
3 time of the data packet for transmission by said transmitting step, D is the delay bound
4 time set for the data packet and T_1 is a threshold value, and
5 the second interval of time expires at a time $A+D-T_2$, where T_2 is a
6 threshold value lower than T_1 .

1 75. A method as in claim 57, wherein said transmitting step transmits
2 data blocks that are sequentially identified, and said retransmitting step is inoperative
3 to retransmit a data block M upon receiving a message that either:
4 data block N has been successfully received, and $M \leq N$, or
5 data block P has been successfully received, and $M \leq P+1$.